

Unified Parameterization of the Marine Boundary Layer

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LONG-TERM GOALS

The long term goals of this effort are (i) the development of a unified parameterization for the marine boundary layer; (ii) the implementation of this new parameterization in the US Navy COAMPS mesoscale model; and (iii) the transition of this new version of the COAMPS model into operations at Fleet Numerical Meteorology and Oceanography Center (FNMOC).

OBJECTIVES

The objectives of this project are: i) to develop a unified parameterization for the Marine Boundary Layer (MBL) and ii) to implement and test this parameterization in the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS^{®1}).

APPROACH

This unified boundary layer parameterization will be based on two main components: (i) the Eddy-Diffusivity Mass-Flux (EDMF) parameterization of boundary layer mixing; and (ii) the Probability Density Function (PDF) cloud parameterization.

Together these two concepts allow for the unification of MBL parameterization in one single scheme. They also allow for the development of physically-based strategies that take into account the horizontal grid-size in the parameterization framework. Such a development would lead to a resolution-dependent MBL parameterization that would adjust itself to the horizontal grid resolution (e.g., tending asymptotically to a Large Eddy Simulation (LES) model parameterization for very high horizontal resolutions of the order of 10 to 100 m).

Key personnel:

J. Teixeira (JPL/Caltech) uses his expertise in cloud and boundary layer parameterizations to guide the development and implementation of the EDMF/PDF parameterization.

¹ COAMPS[®] is a trademark of the Naval Research Laboratory.

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J. Doyle uses his expertise in mesoscale modeling to assist with the investigations related to COAMPS within the context of his existing ONR project.

J. Martins, a graduate student (jointly at Univ. Lisbon, Portugal, and JPL), fully funded by the Portuguese Foundation for Science and Technology (FCT), is working on very high resolution simulations of the transition from shallow to deep convection (see below).

B. Kahn, a research assistant at UCLA Joint Institute for Regional Earth System Science and Engineering (JIFRESSE), is working on the determination of PDF characteristics from high resolution satellite data (see below).

WORK COMPLETED

Tasks completed:

- Performed very high resolution simulations of the transition from shallow to deep convection to be used to evaluate EDMF single-column model simulations;
- Performed study on the determination of PDF characteristics of temperature and humidity variables from the Atmospheric Infrared Sounder (AIRS) satellite dataset;
- Performed EDMF single-column study with a new decomposition between large scales (parameterized by the MF term) and small scales (ED);
- Hired Postdoc, Marcin Witek from Univ. Warsaw, to perform the implementation of the EDMF approach in the COAMPS model.

RESULTS

Meaningful technical results achieved in the fiscal year:

1) The very high resolution (250m X 250m horizontal grid sizes) simulations of the transition from shallow to deep convection allow not only to evaluate the EDMF single-column simulations but also allow the study of boundary layer heterogeneity, and its interaction with deep convection. Boundary layer heterogeneity along with mesoscale organization are major challenges to the traditional assumptions upon which parameterizations are based. Figure 1 shows (in particular) a horizontal cut at $z=1300\text{m}$ of the vertical velocity field (top left) and a cross-section of the moist static energy (bottom right) after deep and mid-level convection starts to develop. Note the typical size of eddies in the vertical velocity plot: after the onset of deep and mid-level convection, boundary layer eddies become much larger (in the horizontal) than the typical convective boundary layer height due to a mesoscale interactions with precipitation. These very high resolution simulations are a new capability for parameterization development and evaluation.

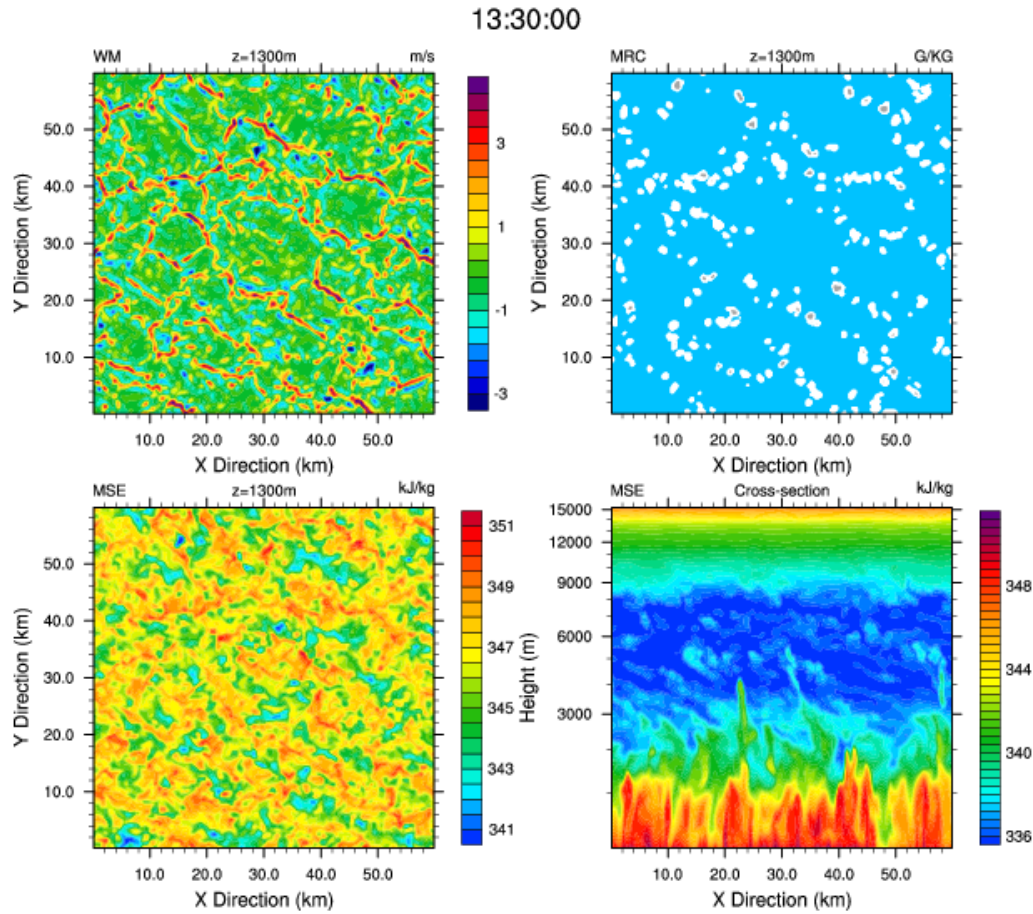


Figure 1 - Horizontal cut at $z=1300\text{m}$ of vertical velocity (top left), horizontal cut at $z=1300\text{m}$ of moist static energy (bottom left), and cross-section of moist static energy (bottom right) after the onset of deep and mid-level convection.

2) We utilize high resolution satellite data sets to produce estimates of the PDFs of thermodynamic variables. This is an important task for the development and evaluation of the new PDF-based cloud parameterizations. In this context we produced estimates of observed variance for temperature and humidity in all regions of the globe and associated with a variety of physical processes. An example of AIRS global observations of variance is illustrated in Fig. 2 where the temperature standard deviation (in latitude/longitude boxes of $2^\circ \times 4^\circ$ degrees) for June-July-August 2006 is shown. These results provide a global perspective of the problem, which is crucial in this project given the global weather interests of the US Navy.

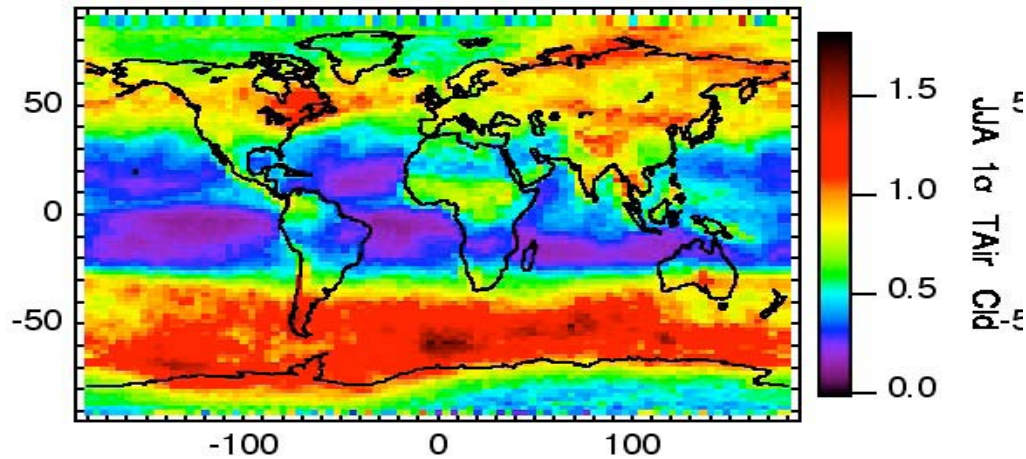


Figure 2 – Standard deviation of temperature (in K), for latitude/longitude grid-boxes of 2X4 degrees, for June-July-August 2006.

IMPACT/APPLICATIONS

These results have an important potential future impact for the weather prediction capabilities of the US Navy after the implementation of these new parameterizations in the COAMPS model.

In addition it will be the first time that a unified parameterization of the marine boundary layer has ever been developed and implemented in a weather prediction model.

TRANSITIONS

This new unified parameterization will be proposed for a transition at FNMOC after implementation and adequate testing in the COAMPS model

RELATED PROJECTS

J. Doyle (NRL) is currently supported by an existing ONR project related to physical parameterizations and numerical techniques for high-resolution next-generation applications of COAMPS

PUBLICATIONS

Brian Kahn and Joao Teixeira, 2008: A global climatology of temperature and water vapor variance scaling from the Atmospheric Infrared Sounder. *Journal of Climate* [refereed].